PA 01/30/02

METHOD OF AND APPARATUS FOR WINDING WEB

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a method of and an apparatus for winding a web around a core.

Description of the Related Art:

It has been known in the art to wind a web such as an elongate film or sheet of paper around a core to produce a high-quality roll which is free of wrinkles and edge undulations or irregularities by winding the web in intimate contact with a contact pressure roller to prevent air from being entrapped in the web as it is wound, thus producing the roll in a well wound state (see Japanese laid-open patent publication No. 11-59985).

According to the known process, since the contact pressure roller is held in direct contact with the web, it tends to degrade the quality of the web particularly if the web is a delicate material such as a film.

There has been proposed in the art a process of winding a web in a manner to prevent the quality of the web from being lowered and also to prevent the web from developing wrinkles. According to the proposed process, the web is wound under a low tension which is 70 % or less of the basic winding tension in an initial web winding stage, and, when the number of turns of the web becomes 1/10 of the number of turns which is to be finally achieved, the winding tension

is sharply returned to the high tension, after which the web is wound under a progressively decreasing tension (see Japanese laid-open patent publication No. 60-112562).

The above proposed process is disadvantageous in that since the winding tension is sharply changed from the low tension to the high tension, the web is subjected to an excessive load and liable to be deteriorated under the excessive load applied thereto. Furthermore, as shown in FIG. 22 of the accompanying drawings, because possible deformation of a core a around which a web f is wound is not taken into account, an end face b of the wound web f may possibly develop edge undulations or irregularities depending on the tension which is applied to the web d while it is being wound. Specifically, if the web a is curved while the web f is being wound, the web f is shifted axially of the core a, producing edge undulations or irregularities on the end face b. Such edge undulations or irregularities cause variations in the width L of the produced roll. Therefore, when the roll is supplied to a subsequent process of packaging the roll in a light-shielded state, the roll may not be packaged well in the light-shielded state for desired performance and may possibly suffer fogging due to exposure to light. In addition, the roll may not well fit an image forming apparatus such as an image setter or the like, e.g., may not be inserted into a magazine which is to be loaded into the image forming apparatus.

A film rewinding machine for automatically winding an

elongate film on a core and a cutting machine for cutting a wide raw film into an elongate film of given width and then automatically winding the elongate film on a core employ a winding mechanism for supporting the elongate film on the outer circumferential surface of the core when the core is rotated in a winding position.

As disclosed in Japanese patent publication No. 57-40052 (hereinafter referred to as "prior art 1"), the winding mechanism has a holder for holding a spool, angularly movably mounted on the distal end of a belt wrapper, and an actuating mechanism for reciprocally moving the belt wrapper until the central axis of the spool held by the holder is aligned with the central axis of a winding barrel.

A strip coiler disclosed in Japanese utility model publication No. 48-38149 (hereinafter referred to as "prior art 2") comprises a mandrel for winding a strip as a coil, a plurality of wrapper rolls and wrapper roll plates disposed around the mandrel, and a fluid pressure cylinder for pressing the wrapper rolls into and retracting the wrapper rolls from a position to start winding the strip.

According to the prior art 1, the belt wrapper has an opening aligned with the direction in which the film enters, i.e., the direction in which the film tension acts. Therefore, when the elongate film is wound around the core (spool), the core may possibly be greatly flexed under the film tension. If the core is flexed, then the film tension

concentrates on the opposite edges of the core, causing the elongate film to run unstably and disturbing the wound configuration of the elongate film.

According to the prior art 2, the strip coiler is designed for the purpose of setting a gap between the mandrel (corresponding to the core) and each wrapper roll depending on the thickness of the strip (corresponding to the elongate film) to be wound in order to keep the strip as it starts to be wound in a good coil configuration. The strip coiler has nothing incorporated therein for preventing the mandrel from being flexed under the strip tension. Stated otherwise, no consideration is given to achieving a balance between the strip tension and the force to press the wrapper rolls, and hence the strip tension tends to act on the mandrel to cause the mandrel to be flexed.

According to the prior art 2, furthermore, gaps are provided between the mandrel and the wrapper rolls and wrapper roll plates, and the strip is wound on the mandrel through the gaps. However, when the elongate film is wound around the core in this manner, the elongate film has difficulty in being held in intimate contact with the outer circumferential surface of the core, and the wound configuration becomes unstable on the end faces of the wound film roll.

SUMMARY OF THE INVENTION

It is a general object of the present invention to

provide a method of and an apparatus for winding a web around a core in a highly neatly wound state without causing damage to the web and forming edge undulations or irregularities on end faces of a roll that is produced of the wound web.

A major object of the present invention is to provide a method of winding a web smoothly and highly accurately around a core in a simple process.

Another object of the present invention is to provide an apparatus for winding a web while reliably preventing the core from being flexed with a simple arrangement.

With a method of and an apparatus for winding a web around a core according to the present invention, the web is wound to a given length around the core under a low tension thereby imparting prescribed rigidity to the core without deforming the core. The length to which the web is wound under the low tension is set so as to correspond to the length of the core, thus preventing a quality failure such as a stepwise web shift on a shorter core.

~~Then, after the tension of the web is progressively increased at a predetermined rate, the tension is reduced at a predetermined rate while the web is being wound around the core. The web is thus wound around the core to which sufficiently rigidity is imparted, without being subjected to an excessive load. As a result, a roll produced by winding the web around the core is free of edge undulations or irregularities on its end faces, and is of a good quality~~

~~free of damage and winding irregularities.~~

In a method of winding a web around a core according to the present invention, a web is supported on the outer circumferential surface of a core by a plurality of rollers, and the core is rotated with a gap being defined by blocks for the passage of the web between the blocks and the outer circumferential surface of the core. The rollers and the blocks are retracted from the core successively from regions where a leading end of the web has passed. After the web is wound around the core by at least one turn, all the rollers and the blocks are retracted from the core.

Since the rollers and the blocks are retracted from the core successively from regions where the leading end of the web has passed, only the leading end of the web is held when the web is initially wound around the core. Therefore, the web is not loosened on the outer circumferential surface of the core under the tension of the web. As a consequence, a high-quality wound product with a desired wound configuration maintained reliably can efficiently be obtained through a simple process.

In an apparatus for winding a web around a core according to the present invention, a winding mechanism for guiding the web around the core when the core is rotated has a movable pressing roller for pressing the web against the core to support the web thereon and for being pressed against the core in a direction opposite to the direction in which the tension of at least the web is applied, and a

plurality of movable blocks for creating a gap for passage of the web between the movable blocks and an outer circumferential surface of the core.

The movable pressing roller presses the core in the direction opposite to the direction in which the tension of the web is applied, to keep the tension of the web and the pressing forces applied by the pressing roller in equilibrium. Consequently, when the web is wound around the core, the core is effectively prevented from being flexed under the tension of the web, making it possible to reliably obtain a stable wound configuration with a simple arrangement.

The above and other objects, features, and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which preferred embodiments of the present invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic elevational view of a film processing and cutting machine to which a method of and an apparatus for winding a web around a core according to a first embodiment of the present invention are applied;

FIG. 2 is a block diagram of a control circuit of a film winding apparatus of the film processing and cutting machine shown in FIG. 1;

FIG. 3 is a diagram showing the relationship between

speed command values for feeding a film and winding tension command values in the control circuit of the film winding apparatus of the film processing and cutting machine shown in FIG. 1;

FIG. 4 is an elevational view of a film winding apparatus according to a second embodiment of the present invention;

FIG. 5 is a perspective view of a core rotating mechanism of the film winding apparatus;

FIG. 6 is a plan view of the core rotating mechanism;

FIG. 7 is a perspective view of a block wrapper and a first unit body of a film winding mechanism;

FIG. 8 is a side elevational view showing a structure of the block wrapper;

FIG. 9 is a perspective view of a winding nip roller unit of the film winding apparatus;

FIG. 10 is a perspective view of a cutting mechanism of the film winding apparatus;

FIG. 11 is a view illustrative of the manner in which an elongate film starts being wound around a core;

FIG. 12 is a view illustrative of the manner in which the winding nip roller unit is released from the core;

FIG. 13 is a view illustrative of the manner in which a side wrapper is released from the core;

FIG. 14 is a view illustrative of the manner in which an upper wrapper is released from the core;

FIG. 15 is a view illustrative of the manner in which

the elongate film is wound around the core;

FIG. 16 is a view illustrative of the manner in which a film roll made of the elongate film wound around the core is discharged;

FIG. 17 is a view illustrative of the manner in which the elongate film is cut from the film roll;

FIG. 18 is a view illustrative of the manner in which the end of the cut elongate film is wound, producing the film roll;

FIG. 19 is a perspective view showing the manner in which the elongate film is wound around the core without using the block wrapper;

FIG. 20 is a perspective view showing the manner in which the elongate film is wound around the core using the block wrapper;

FIG. 21 is a view of another winding nip roller unit; and

FIG. 22 is a perspective view illustrative of the manner in which a roll is produced by winding a web around a core.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows in schematic elevation a film processing and cutting machine 12 which incorporates film (web) winding apparatus 10 according to a first embodiment of the present invention.

The film processing and cutting machine 12 has a film

delivery apparatus 18 for rotating film rolls 14, each in the form of a photosensitive roll (hereinafter referred to as "film roll") of a PET (polyethylene terephthalate) film, a TAC (triacetylcellulose) film, a PEN (polyethylene naphthalate) film, or a photographic printing sheet used as a base, while being kept under suitable back tension to deliver an elongate raw film (raw web) 16; a feed apparatus 20 for feeding the elongate raw film 16 successively to next processes; a cutting apparatus 26 for cutting the elongate raw film 16 fed by the feed apparatus 20 at transversely spaced intervals into a plurality of elongate film blanks and cutting off film edges from the elongate film blanks, thus producing a plurality of elongate films (elongate webs) 24a through 24d (in the first embodiment, four elongate films 24a through 24d) having given widths; film winding apparatus 10 for winding the elongate films 24a through 24d around respective cores 28a through 28d and cutting the elongate films 24a through 24d to given lengths, thereby producing rolls 30a through 30d as products; and an edge processing apparatus 34 for processing unwanted edges (film edges) 32 discharged from the elongate raw film 16.

The film delivery apparatus 18 has a turret shaft 36 by which a pair of film rolls 14 is supported for indexed movement. The film rolls 14 are selectively unwound by an unwinding motor (not shown). The feed apparatus 20 has a suction drum (reference roller) 38 serving as a main feed roller and a plurality of rollers 40. The suction drum 38

is controlled in speed to rotate according to a predetermined pattern of peripheral speeds by a servomotor (described later on). An encoder 41 is connected to the shaft (not shown) of the suction drum 38.

One of the rollers 40 which are disposed between the film roll 14 in operation and the suction drum 38 is associated with a tension detector (tension pickup) 42. The tension of the film between the film roll 14 and the suction drum 38 is controlled by the tension detector 42 and the unwinding motor mounted on the shaft of the film roll 14. Near the turret shaft 36, there are disposed an EPC (edge position control) sensor 44 for detecting the position of an end of the elongate raw film 16 to adjust the position of the end and a splicing suction table 46 for splicing the trailing end of the elongate raw film 16 to the leading end of a new elongate raw film 16 from the other film roll 14.

The cutting apparatus 26 has a plurality of rotary cutters 48a, 48b selectively positioned in cutting positions corresponding to film widths to be achieved, for cutting the elongate raw film 16 at transversely spaced intervals. The cutting apparatus 26 includes, in its lower portion, separation rollers 50a, 50b for separating severed elongate films 24a through 24d away from each other. The film winding apparatus 10 are disposed downstream of the separation rollers 50a, 50b with nip roller pairs 52a, 52b interposed therebetween.

In FIG. 1, there are two left and right film winding

apparatus 10 associated with the elongate films 24a through 24d. The film winding apparatus 10 have a core rotating mechanism 58 for holding and rotating cores 28a through 28d, a plurality of block wrappers (winding mechanisms) 60 for winding the elongate films 24a through 24d to a given length around the cores 28a through 28d to produce rolls 30a through 30d, a product receiving mechanism 64 for gripping the circumferential surfaces of the elongate films 24a through 24d wound around the cores 28a through 28d while applying a certain tension to the elongate films 24a through 24d, the product receiving mechanism 64 being relatively movable away from the block wrappers 60, a cutting mechanism 66 for transversely cutting the elongate films 24a through 24d while they are being tensioned by the product receiving mechanism 64, and a core supply mechanism 68 for automatically supplying the cores 28a through 28d to the block wrappers 60.

Operation of the film processing and cutting machine 12 thus constructed will briefly be described below.

A film roll 14 mounted on the film delivery apparatus 18 is unwound by the non-illustrated unwinding motor to supply an elongate raw film 16 to the suction drum 38 of the feed apparatus 20. The speed of the suction drum 38 is controlled according to a given speed pattern by the servomotor, described later on, and the length of the elongate raw film 16 as it is fed (the length of the elongate raw film 16 as it is wound) is detected by the

encoder 41.

The elongate raw film 16 which is adjusted in speed by the suction drum 38 is fed to the cutting apparatus 26. The rotary cutters 48a, 48b are rotated to cut the edges 32 off the elongate raw film 16 and produce four elongate films 24a through 24d, which are fed to the film winding apparatus 10.

In the film winding apparatus 10, while the outer circumferential surfaces of cores 28a through 28d are being held by the block wrappers 60, the suction drum 38 is rotated and the cores 28a through 28d are rotated by the core rotating mechanism 58. The elongate films 24a through 24d are now wound respectively around the cores 28a through 28d. After the block wrappers 60 are spaced away from the respective cores 28a through 28d, the elongate films 24a through 24d are wound to a given length around the cores 28a through 28d, producing rolls 30a through 30d.

The product receiving mechanism 64 is elevated to hold the rolls 30a through 30d, which are lowered as they are unwinding the elongate films 24a through 24d. The cutting mechanism 66 is actuated to cut (cross-cut) the elongate films 24a through 24d in their transverse direction. Now, products comprising the rolls 30a through 30d are obtained, and supplied to a next process. The block wrappers 60 are automatically supplied with new 28a through 28d, and restart a next winding process.

Unless the tension applied to the elongate films 24a through 24d is adjusted to an appropriate level when they

are wound as described above, the elongate films 24a through 24d tend to be damaged due to excessive tension or the obtained rolls 30a through 30d are liable to be loosened or suffer edge undulations or irregularities. According to the first embodiment, these drawbacks are avoided by arranging and controlling the film winding apparatus 10 as follows:

FIG. 2 shows in block form a control circuit 1000 of the film winding apparatus 10. The control circuit 1000 has a speed controller 1002 for controlling the rotational speed of the suction drum 38, and speed and torque controllers (core rotation control means) 1004a through 1004d for controlling the rotational speeds and torques of the cores 28a through 28d in the core rotating mechanism 58.

A process control computer 1008 to which a management computer 1010 is connected is connected to the control circuit 1000 through an input unit 1006. The process control computer 1008 performs process control in the film winding apparatus 10. The film processing and cutting machine 12 has process control computers 1008 associated with respective processes. The management computer 1010 serves to manage all the process control computers 1008 of the film processing and cutting machine 12.

A motor driver 1014 is connected to the speed controller 1002 through an output unit 1012. The motor driver 1014 is also connected to a servomotor 1016 for rotating the suction drum 38. To the speed controller 1002, there is connected a speed command value memory 1018 for

storing a speed command value supplied from the process control computer 1008. The servomotor 1016 is controlled according to the speed command value stored in the speed command value memory 1018.

Motor drivers 1026a through 1026d are connected to the respective speed and torque controllers 1004a through 1004d through respective output units 1024a through 1024d. The motor drivers 1026a through 1026d are connected to respective servomotors 1028a through 1028d for winding elongate films 24a through 24d around cores 28a through 28d. To the speed and torque controllers 1004a through 1004d, there are connected respective speed command value memories 1030a through 1030d for storing speed command values supplied from the process control computers 1008, and respective winding tension command value memories (winding tension storing means) 1032a through 1032d for storing winding tension command values supplied from the process control computers 1008, through respective torque converting units (torque converting means) 1034a through 1034d. The servomotors 1028a through 1028d are controlled according to speed command values supplied from the speed and torque controllers 1004a through 1004d and winding tension command values converted by the torque converting units 1034a through 1034d.

A process of controlling the film winding apparatus 10, which is carried out by the control circuit 1000, will be described below.

Prior to a process of winding the elongate films 24a through 24d with the film winding apparatus 10, the process control computer 1008 stores preset speed command values and preset winding tension command values in the speed command value memory 1018, the speed command value memories 1030a through 1030d, and the winding tension command value memories 1032a through 1032d.

FIG. 3 shows in an upper portion thereof the relationship between speed command values for the servomotor 1016 which are stored in the speed command value memory 1018 and time, and FIG. 3 shows in a lower portion thereof the relationship between winding tension command values for the elongate films 24a through 24d which are stored in the winding tension command value memories 1032a through 1032d and time. The speed command value memories 1030a through 1030d store a constant speed command value for the servomotors 1028a through 1028d.

The speed and torque controllers 1004a through 1004d read a constant speed command value from the speed command value memories 1030a through 1030d, supply a drive signal based on the speed command value from the output units 1024a through 1024d via the motor drivers 1026a through 1026d to the servomotors 1028a through 1028d to rotate the cores 28a through 28d.

The torque converting units 1034a through 1034d read a constant winding tension command value T1 shown in FIG. 3 from the winding tension command value memories 1032a

through 1032d, convert the winding tension command value T1 into a torque command value, and supply the torque command value to the speed and torque controllers 1004a through 1004d. The speed and torque controllers 1004a through 1004d control the motor drivers 1026a through 1026d to rotate the servomotors 1028a through 1028d with the torque command supplied from the torque converting units 1034a through 1034d.

After the core rotating mechanism 58 has been adjusted to the above state, the speed controller 1002 reads a speed command value from the speed command value memory 1018 at a time t1, and supplies a drive signal based on the speed command value from the output unit 1012 via the motor driver 1014 to the servomotor 1016 thereby rotating the suction drum 38. The suction drum 38 is accelerated from the time t1 to a time t2, and then rotated at a constant speed v1 to deliver the elongate raw film 16 to the film winding apparatus 10.

The elongate raw film 16 delivered by the suction drum 38 is cut by the cutting apparatus 26 into four elongate films 24a through 24d, which are then supplied to the core rotating mechanism 58 of the film winding apparatus 10. Then, the elongate films 24a through 24d start being wound around the cores 28a through 28d that are rotated by the servomotors 1028a through 1028d. Since the servomotors 1028a through 1028d are controlled to produce a torque value which is equal to a constant torque command value that is

obtained by converting the constant winding tension command value T1, a constant tension T1 is applied to the elongate films 24a through 24d when they are wound around the cores 28a through 28d.

Then, the speed controller 1002 reads a speed command value from the speed command value memory 1018, and accelerates the suction drum 38 from a speed v1 to a speed v2 in an interval from a time t3 to a time t6, delivering the elongate raw film 16 to the film winding apparatus 10.

The torque converting units 1034a through 1034d convert a winding tension command value, which gradually increases from the winding tension command value T1 read from the winding tension command value memories 1032a through 1032d to a winding tension command value T3 set depending on the length of the cores 28a through 28d during an interval from a time t4 to a time t5 which is set depending on the length of the cores 28a through 28d, into a torque command value. The speed and torque controllers 1004a through 1004d then supply the torque command value to the motor drivers 1026a through 1026d to control the servomotors 1028a through 1028d. As a result, the elongate films 24a through 24d are wound around the respective cores 28a through 28d under winding tensions T1 through T3 which gradually increase.

When a time t5 is reached, the speed and torque controllers 1004a through 1004d gradually reduce the torque command value from the value corresponding to the winding tension command value T3, and winds the elongate films 24a

through 24d.

During this time, the acceleration to deliver the elongate raw film 16 with the servomotor 1016 based on the command from the speed controller 1002 is gradually reduced. At a time t6, the speed command value from the speed controller 1002 is set to a constant speed command value v2. The speed command value v2 is kept until a time t7, and thereafter reduced to the speed command value v1 at a time t8 and then to 0 at a time t9.

During an interval from the time t5 to the time 59, the speed and torque controllers 1004a through 1004d gradually reduce the torque command value from the value corresponding to the winding tension command value T3 to the value corresponding to the winding tension command value T2, and thereafter set the torque command value to the value corresponding to the winding tension command value T1.

The elongate films 24a through 24d are thus wound around the respective cores 28a through 28d while the tension applied to the elongate films 24a through 24d is being adjusted in the manner described above, thereby producing neatly wound rolls 30a through 30d.

Specifically, when the elongate films 24a through 24d start being wound around the respective cores 28a through 28d, the winding tension command value T1 applied to the elongate films 24a through 24d is kept low. Since no large external forces are imposed on the cores 28a through 28d which are not given sufficient rigidity by the elongate

films 24a through 24d, the cores 28a through 28d are not flexed, and hence the elongate films 24a through 24d are neatly wound around the respective cores 28a through 28d.

When the elongate films 24a through 24d are wound to a certain length around the respective cores 28a through 28d, they impart rigidity to the cores 28a through 28d, making the cores 28a through 28d resistant to flexing. The tension of the elongate films 24a through 24d is then switched to the higher winding tension command value T3, allowing the elongate films 24a through 24d to be wound at a high speed around the cores 28a through 28d without being made unstable by becoming loose. For longer cores 28a through 28d, the length of the elongate films 24a through 24d wound under the lower winding tension command value T1 is set to a larger value, so that the elongate films 24a through 24d can be wound around the cores 28a through 28d without flexing the cores 28a through 28d.

For shorter cores 28a through 28d, since the shorter cores 28a through 28d are sufficiently rigid, the length of the elongate films 24a through 24d wound under the lower winding tension command value T1 is set to a smaller value, and the higher winding tension command value T3 switched from the lower winding tension command value T1 is set to a larger value. Thus, the elongate films 24a through 24d are prevented from being displaced while they are being wound, and can be neatly wound around the cores 28a through 28d.

In the first embodiment, when the winding tension

command value is increased from the value T1 to the value T3, it is increased gradually at a certain rate without abrupt tension variations. Consequently, the elongate films 24a through 24d are wound around the respective cores 28a through 28d without being damaged.

After the tension of the elongate films 24a through 24d has reached the winding tension command value T3, the elongate films 24a through 24d are wound while their tension is being gradually reduced. In this manner, the elongate films 24a through 24d are wound without being displaced and the ends of the rolls 30a through 30d are not disturbed or undulated, so that the rolls 30a through 30d are in a held in a very neatly wound state.

The winding tension values stored in the winding tension command value memories 1032a through 1032d may be set to individual values for the respective rolls 30a through 30d and may be independently controlled.

Examples under specific conditions will be described below.

1st Example

For winding elongate films 24a through 24d having a width of 1220 mm around respective cores 28a through 28d having a length of 1220 mm and an outside diameter of 3 inches, the elongate films 24a through 24d were wound to a length of 8 m (about 30 turns) under a tension T1 = 7.84 N/100 mm, and then wound to 10 m while increasing the tension from T1 to a tension T3 = 17.64 N/mm. Then, while

gradually reducing the tension T3 at a rate of 20 %, the elongate films 24a through 24d were wound to 61 m, producing rolls 30a through 30d. The number of turns wound under the low tension T1 was about 15 % of the entire number of turns.

In 1st Example, though the cores 28a through 28d were elongate and liable to be flexed, any disturbance or undulation on the ends of the rolls 30a through 30d was less than a target value of 0.5 mm. The elongate films 24a through 24d were not displaced on the cores 28a through 28d, and sufficiently neatly wound around the respective cores 28a through 28d.

2nd Example

For winding elongate films 24a through 24d having a width of 150 mm around respective cores 28 having a length of 150 mm and an outside diameter of 3 inches, the elongate films 24a through 24d were wound to about one-half of a turn around the cores 28a through 28d under a tension T1 = 7.84 N/100 mm, and then wound while increasing the tension from T1 to a tension T3 = 24.5 N/mm. Then, while gradually reducing the tension T3 at a rate of 20 %, the elongate films 24a through 24d were wound to 61 m, producing rolls 30a through 30d. The number of turns wound under the low tension T1 was about 0.5 % of the entire number of turns.

In 2nd Example, because the cores 28a through 28d were short and less liable to be flexed, the elongate films 24a through 24d could be wound under a high tension from the start of the winding process, producing neat rolls 30a

through 30d whose elongate films 24a through 24d were not disturbed or undulated and displaced.

Other Examples are shown in Table 1 below. In these Examples, the cores 28a through 28d had an inside diameter of 73.7 mm, an outside diameter of 77.9 mm, and a length of which was 0.5 to 1.0 mm smaller than the width of the elongate films 24a through 24d. By setting the length of the elongate films 24a through 24d to be wound around cores 28a through 28d under the low tension T1 as shown in Table 1 with respect to the overall length of rolls 30a through 30d, any disturbance or undulation of the ends of the rolls could be held to an allowable range of 0.5 mm.

Table 1

Axial film length	Winding ratio under low tension T1
310 mm	0.5 %
381 mm	0.5 %
761 mm	0.5 %
838 mm	0.5 %
1220 mm	1.5 %

FIG. 4 shows a film (web) winding apparatus 10a according to a second embodiment of the present invention. In a similar manner to the film winding apparatus 10 according to the first embodiment, the film winding apparatus 10a is incorporated in the film processing and cutting machine 12. Those parts of the film winding apparatus 10a which are identical to those of the film

winding apparatus 10 are denoted by identical reference characters, and will not be described in detail below.

As shown in FIG. 4, a nip roller pair 52a comprises a backup roller 54 connected to a rotary actuator (not shown) and a nip roller 56 movable toward and away from the backup roller 54. The backup roller 54 has its peripheral speed set such that its feed speed in the direction indicated by the arrow B is higher than the suction drum 38. When the nip roller 56 is pressed against the backup roller 54 in sandwiching relation to the elongate films 24a, 24b, a certain tension is applied to elongate films 24a, 24b as they are fed into the cutting apparatus 26 though no tension is applied to the elongate films 24a, 24b downstream of the nip roller 56.

As shown in FIG. 5, the core rotating mechanism 58 has two cores 28a, 28b disposed coaxially with each other and positionally adjustable by two guide rails 72a, 72b and a ball screw 74 which extend in the directions indicated by the arrow D (axial directions of the cores 28a, 28b) for simultaneously winding the elongate films 24a, 24b around the respective cores 28a, 28b.

As shown in FIGS. 5 and 6, the core rotating mechanism 58 has two movable bases 76a, 76b supported on the guide rails 72a, 72b and the ball screw 74. The movable bases 76a, 76b support thereon respective nuts 78a, 78b threaded over the ball screw 74 and respective servomotors 82a, 82b for rotating the respective nuts 78a, 78b individually

through belt and pulley means 80a, 80b, respectively.

Cylinders 84a, 84b are fixed respectively to the movable bases 76a, 76b and have respective rods 86a, 86b projecting therefrom to which respective take-up arms 88a, 88b are secured. Core chucks 90a, 90b are rotatably mounted on the respective take-up arms 88a, 88b. The core chuck 90a can be rotated by a servomotor 92.

The servomotor 92 is fixedly mounted on the movable base 76a and has a drive shaft 94 to which a rotary tube 98 is coupled by a belt and pulley means 96. The rotary tube 98 is supported on the movable base 76a and has spline grooves defined in its inner circumferential surface, and a spline shaft 100 is fitted in the spline grooves. The spline shaft 100 is rotatably supported on a casing 102 fixed to the take-up arm 88a. The core chuck 90a is coupled to an end of the spline shaft 100 by a belt and pulley means 104.

As shown in FIG. 7, the block wrappers 60 are individually movable on a unit body 200 in the directions indicated by the arrow C which are transverse to the axial directions of cores 28a, 28b (the directions indicated by the arrow D). The unit body 200 is movable in the directions indicated by the arrow C by a drive means 202. The drive means 202 has a pair of frames 204 spaced from each other by a certain distance in the directions indicated by the arrow D. A servomotor 206 is mounted on at least one of the frames 204. The servomotor 206 has a drive shaft 208

to which a ball screw 212 is coupled through a belt and pulley means 210. The ball screws 212 are rotatably supported on upper surfaces of the frames 204, and are threaded through respective nuts (not shown) mounted on movable bodies 214. Each of the movable bodies 214 is supported on a guide rail 216 mounted on one of the frames 204.

The unit body 200 is removably fixed between the movable bodies 214. Each of the block wrappers 60 can be fixed to the unit body 200 selectively in a winding position P1 and a retracted position P2.

As shown in FIG. 8, the block wrappers 60 have respective upper wrappers 300 mounted on a base 254 and vertically movable by a lifting and lowering means 302, and side wrappers 304 mounted on the base 254 and horizontally movable by a moving means 306. The lifting and lowering means 302 has a rectangular support tube 308 mounted on the base 254 and extending vertically upwardly, and an actuator with a pressing force adjusting function in the form of a vertical cylinder 310, for example, is fixed to a side panel of the rectangular support tube 308. The cylinder 310 has an upwardly extending rod 312 to which there is fixed a vertically movable base 314 that is vertically movably supported on a guide rail 316 fixedly mounted another side panel of the rectangular support tube 308. Each of the upper wrappers 300 is mounted on the lower surface of a distal end portion of the vertically movable base 314.

Each of the upper wrappers 300 has a block 317 fixed to the vertically movable base 314. The block 317 has a guide surface 318 on its end close to the cores 28a, 28b which has a radius of curvature slightly greater than the radius of curvature of the outer circumferential surface of the cores 28a, 28b. A gap 319 for passing the elongate films 24a, 24b therethrough is defined between the guide surface 318 and the cores 28a, 28b. First and second free rollers (first and second pressing rollers) 320a, 320b are rotatably supported on the block 317 and positioned on the guide surface 318 for pressing the elongate films 24a, 24b against the outer circumferential surface of the cores 28a, 28b. The first and second free rollers 320a, 320b are movable toward and away from the cores 28a, 28b and can be pressed against the cores 28a, 28b in the direction indicated by the arrow V2 which is opposite to the direction indicated by the arrow V1 in which the elongate films 24a, 24b are tensioned.

The first and second free rollers 320a, 320b are symmetrically positioned with respect to a hypothetical reference line LV which extends parallel to the direction indicated by the arrow V1 in which the elongate films 24a, 24b are tensioned and also extends through centers of the cores 28a, 28b. Specifically, the first and second free rollers 320a, 320b are axially symmetrically positioned at equal distances K from the hypothetical reference line LV extending across the cores 28a, 28b.

The moving means 306 comprises an actuator with a

pressing force adjusting function in the form of a horizontal cylinder 322, for example, mounted on the base 254. The cylinder 322 has a horizontally extending rod 324 to which there is fixed a movable base 326 that is supported on a rail 328 on the base 254 for movement in the directions indicated by the arrow C. Each of the side wrappers 304 is mounted on the movable base 326.

Each of the side wrappers 304 has a block 329 having a guide surface 330 on its end close to the cores 28a, 28b which has a radius of curvature slightly greater than the radius of curvature of the outer circumferential surfaces of the cores 28a, 28b. A gap 331 for passing the elongate films 24a, 24b therethrough is defined between the guide surface 330 and the cores 28a, 28b. Third and fourth free rollers 332, 334 are rotatably supported on the block 329 and positioned on the guide surface 330.

The third free roller 332 as a third pressing roller is disposed on a hypothetical line LH that extends diametrically across the cores 28a, 28b transversely to the hypothetical reference line LV. The fourth free roller 334 as a receiving roller is disposed in engagement with the cores 28a, 28b in substantially opposite relation to the first and second free rollers 320a, 320b about the cores 28a, 28b. The fourth free roller 334 is supported on a swing block 336 for angular movement with respect to the side wrapper 304. An air cylinder 338 as an air spring abuts against the swing block 336 for reliably holding the

fourth free roller 334 against the cores 28a, 28b even if the cores 28a, 28b have a slightly different outside diameter.

As shown in FIG. 4, a winding nip roller unit 400 serving as a winding mechanism is incorporated in a position confronting the block wrappers 60. As shown in FIGS. 4 and 9, the winding nip roller unit 400 comprises winding nip rollers (pressing rollers) 402 disposed in confronting relation to the third free roller 332 for pressing and supporting the elongate films 24a, 24b on the outer circumferential surface of the cores 28a, 28b, and lower winding rollers (pressing rollers) 404 for causing ends of the cut elongate films 24a, 24b to extend along the outer circumferential surfaces of the cores 28a, 28b. For example, 14 winding nip rollers 402 and 14 lower winding rollers 404 are arrayed in the directions indicated by the arrow D in association with the respective block wrappers 60.

An upper plate 408 is fixed to a unit body 406 of the winding nip roller unit 400, and the winding nip rollers 402 are individually rotatably mounted on the distal end of the upper plate 408. A movable lower plate 410 is disposed below the upper plate 408 for movement along a linear guide 412 in the directions indicated by the arrow C. A pair of cylinders 414 is fixed to the upper plate 408 and has rods 416 extending therefrom which are fixed to the lower plate 410.

A swing arm 420 is swingably supported on a distal end of the lower plate 410 by a spring 418. The lower winding rollers 404 are rotatably mounted on a distal end of the swing arm 420. A pair of racks 422 is fixed to the lower plate 410, and the upper plate 408 has openings 424 defined therein in alignment with the respective racks 422. Pinions 426 are held in mesh with the respective racks 422 through the openings 424. The pinions 426 are integrally supported by a rod 428.

The unit body 406 incorporates the cutting mechanism 66. As shown in FIGS. 4 and 10, the cutting mechanism 66 comprises a rodless cylinder 430 mounted on the unit body 406 by a rod 432 which extends axially of the cores 28a, 28b in the directions indicated by the arrow D. A base member 434 is fixed to the rodless cylinder 430 and guided along a linear guide 436 in the directions indicated by the arrow D. Parallel to the linear guide 436, there extends a rack 438 meshing with a first pinion 440 which is held in mesh with a second pinion 442.

A disk-shaped cross cutter blade 446 is fixed to the second pinion 442. A sorting guide 448 for guiding the elongate films 24a, 24b is disposed at a distal end of the cross cutter blade 446. The elongate films 24a, 24b may be cut off by the cross cutter blade 446 alone or the cross cutter blade 446 as an upper blade and a lower blade disposed in confronting relation to the upper blade. The rodless cylinder 430 may be replaced with a motor, a timing

belt, and a pulley for moving the base member 434.

A free roller 450 supported on the unit body 406 is disposed below the cutting mechanism 66 (see FIG. 4).

As shown in FIG. 4, the product receiving mechanism 64 has a vertically movable frame 500 which can be stopped selectively in four positions, i.e., in an upper end position, an intermediate standby position, a film cutting position, and a lower end position, by a servomotor 502. The servomotor 502 has a drive shaft 504 operatively connected to a vertical ball screw 506 that is threaded through a nut 508 mounted on the vertically movable frame 500.

To the vertically movable frame 500, there is fixed a cylinder 510 having an upwardly extending rod 512 coupled to a block 514. A first arm 516 extends upwardly from the block 514 and supports on its distal end an ejection roller 518 to which a tensioning servomotor 520 is coupled by a belt and pulley means 522. The block 514 includes a second arm 524 with a free roller 526 rotatably supported on its distal end.

Between the first and second arms 516, 524, there is disposed a conveyor 528 for ejecting products. To the vertically movable frame 500, there is secured a cylinder 530 having an upwardly extending rod 532 to which a rider roller 538 is connected by a swing arm 536.

The core supply mechanism 68 has a pusher 550 of a comb-toothed structure having teeth aligned with the

respective gaps between the block wrappers 60 for smoothly supplying cores 28a, 28b to a core transfer position P3.

Operation of the film winding mechanism 10a thus constructed will be described below.

When the elongate films 24a, 24b are wound around the cores 28a, 28b in the film winding apparatus 10a, as shown in FIG. 11, the cores 28a, 28b are placed in the winding position with their circumferential surface gripped by the block wrapper 60, and the opposite ends of the cores 28a, 28b are supported by the core chucks 90a, 90b.

In the winding nip roller unit 400, the unit body 406 is moved to move the winding nip roller 402 toward the cores 28a, 28b, thus supporting the elongate films 24a, 24b on the outer circumferential surfaces of the cores 28a, 28b. As shown in FIG. 9, the cylinder 414 is actuated to move the lower plate 410 forward in the direction indicated by the arrow C1 with respect to the upper plate 408, causing the lower winding roller 404 mounted on the lower plate 410 to wind the leading end portions of the elongate films 24a, 24b around the cores 28a, 28b through an angular range of about 90°.

Then, the suction drum 38 is rotated, and the drive torque of the servomotor 92 enables the belt and pulley means 104 to start rotating the core chuck 90a, as shown in FIGS. 5 and 6. The cores 28a, 28b are now rotated to wind the elongate films 24a, 24b around the cores 28a, 28b through about 180° from the position where the elongate

films 24a, 24b have been held by the lower winding roller 404 (the elongate films 24a, 24b are actually wound around the cores 28a, 28b through about 270°), after which the winding nip roller 402 and the lower winding roller 404 of the winding nip roller unit 400 are spaced away from the cores 28a, 28b (see FIG. 12).

The servomotor 92 is energized to wind the elongate films 24a, 24b around the cores 28a, 28b further through about 90° (a total of about 360°). Thereafter, as shown in FIG. 13, the side wrapper 38 of each block wrapper 60 is moved away from the cores 28a, 28b by the cylinder 322. When one turn or more of the elongate films 24a, 24b is subsequently wound around the cores 28a, 28b, as shown in FIG. 14, the upper wrapper 300 of each block wrapper 60 is retracted upwardly by the cylinder 310, and the nip roller 56 is spaced away from the backup roller 54.

As described above, when the elongate films 24a, 24b start being wound around the cores 28a, 28b, as shown in FIG. 11, the upper wrapper 300, the side wrapper 304, the winding nip roller 402, and the lower winding roller 404 of the winding mechanism are positioned around the cores 28a, 28b. Then, the core rotating mechanism 58 is actuated to rotate the cores 28a, 28b in the direction indicated by the arrow E in FIG. 12 to wind the elongate films 24a, 24b around the cores 28a, 28b, and the upper wrapper 300, the side wrapper 304, the winding nip roller 402, and the lower winding roller 404 are successively retracted from the cores

28a, 28b.

Specifically, after the elongate films 24a, 24b are wound around the cores 28a, 28b through about 180° from the position where the elongate films 24a, 24b have been held by the lower winding roller 404, the winding rip roller 402 and the lower winding roller 404 are spaced away from the cores 28a, 28b. After the elongate films 24a, 24b are wound around the cores 28a, 28b further through about 90°, the side wrapper 304 is spaced away from the cores 28a, 28b. When one turn or more of the elongate films 24a, 24b is subsequently wound around the cores 28a, 28b (e.g., through about 540°), the upper wrapper 300 is spaced away from the cores 28a, 28b.

Therefore, when the elongate films 24a, 24b are initially wound, the leading ends of the elongate films 24a, 24b are pressed against and supported by the first through fourth free rollers 320a, 320b, 332, 334 of the block wrapper 60, without sagging in the gaps 319, 331 between the blocks 317, 329 and the cores 28a, 28b. Stated otherwise, since the elongate films 24a, 24b are wound around the cores 28a, 28b with only their leading end being held in position, the elongate films 24a, 24b are prevented from sagging under their tension, making it possible to efficiently produce high-quality rolls 30a, 30b in a desired wound configuration that is reliably maintained through a simple process.

The times at which the upper wrapper 300, the side wrapper 304, the winding nip roller 402, and the lower

winding roller 404 are moved are set based on the output signal from the encoder 41 that is coupled to the suction drum 38 which serves as a reference roller. The wound state of the elongate films 24a, 24b around the cores 28a, 28b can be accurately detected, and the wrappers and the rollers can optimally be retracted based on the detected wound state of the elongate films 24a, 24b, effectively avoiding winding failures of the elongate films 24a, 24b. Consequently, the elongate films 24a, 24b can smoothly be wound around the cores 28a, 28b in a stable wound configuration, producing high-quality rolls 30a, 30b.

While the elongate films 24a, 24b are being wound around the cores 28a, 28b by the core rotating mechanism 58, the unit body 200 on which the block wrappers 60 are mounted is temporarily moved in a direction away from the cores 28a, 28b, i.e., in the direction indicated by the arrow C1 in FIG. 7, by the ball screw 212 that is rotated by the servomotor 206 through the belt and pulley means 210. As shown in FIG. 15, the pusher 550 of the core supply mechanism 68 holds new cores 28a, 28b and moves upwardly, and places the new cores 28a, 28b in the core transfer position P3.

When the new cores 28a, 28b are placed in the core transfer position P3, a given number of block wrappers 60 positioned along the axial length of the cores 28a, 28b are moved in unison with each other to the core transfer position P3 by the unit body 200. Thereafter, as shown in

FIG. 8, the cylinder 310 of the lifting and lowering means 302 is actuated to lower the upper wrapper 300 to support upper portions of the cores 28a, 28b. Then, the core supply mechanism 68 releases the cores 28a, 28b, and the cylinder 322 of the moving means 306 is actuated to move the side wrapper 304 forward, supporting side and lower portions of the cores 28a, 28b (see FIG. 16). The pusher 550 is lowered, thereby transferring the new cores 28a, 28b to the block wrappers 60.

When the elongate films 24a, 24b are wound to a given length around the cores 28a, 28b by the core rotating mechanism 58, as shown in FIG. 16, the nip roller 56 is moved toward the backup roller 54, suppressing tension variations in an upstream film path portion, and the product receiving mechanism 64 is elevated. On the product receiving mechanism 64, the rolls 30a, 30b are held by the rider roller 538, the ejection roller 518, and the free roller 526. The servomotor 502 is energized to rotate the balls crew 506, causing the block 514 to lower the rolls 30a, 30b to a vertical cutting position. At this time, since the rolls 30a, 30b are lowered while unwinding the elongate films 24a, 24b, the elongate films 24a, 24b are kept under tension.

Then, the drive unit 202 is actuated to move the unit body 200 forward in the direction indicated by the arrow C2, and new cores 28a, 28b are held by the core rotating mechanism 58. The unit body 406 is moved forward to cause

the winding nip roller 402 to press the elongate films 24a, 24b against the outer circumferential surfaces of the cores 28a, 28b.

Then, as shown in FIG. 10, the rodless cylinder 430 of the cutting mechanism 66 is actuated, moving the base member 434 in unison therewith in the transverse directions of the film, i.e., in the directions indicated by the arrow D. Therefore, the first pinion 440 meshing with the rack 438 extending in the directions indicated by the arrow D and the second pinion 442 meshing with the first pinion 440 are rotated to rotate and move the cross cutter blade 446 in the directions indicated by the arrow D, cross-cutting the elongate films 24a, 24b transversely while they are being guided by the sorting guide 448.

After the elongate films 24a, 24b are cut, as shown in FIG. 9, the cylinder 414 is actuated to move the lower winding roller 404 in unison with the lower plate 410 forward in the direction indicated by the arrow C1. Therefore, as shown in FIG. 17, the cut leading end portions of the elongate films 24a, 24b are wound around the cores 28a, 28b through about 90°.

Then, as shown in FIG. 18, the elongate films 24a, 24b are wound around the cores 28a, 28b. On the product receiving mechanism 64, the servomotor 520 is energized to rotate the product in the winding direction, winding the cut trailing ends of the elongate films 24a, 24b to a suitable length. The product is transferred from the product

receiving mechanism 64 to the conveyor 528, which supplies the product to a next process.

In the second embodiment, as shown in FIG. 8, the first and second free rollers 320a, 320b are pressed against the outer circumferential surfaces of the cores 28a, 28b, and the direction in which the first and second free rollers 320a, 320b are pressed, i.e., the direction indicated by the arrow V2, is opposite to the direction in which the elongate films 24a, 24b wound around the cores 28a. 28b are tensioned, i.e., the direction indicated by the arrow V1.

Consequently, the first and second free rollers 320a, 320b are capable of applying pressing forces to the cores 28a, 28b while counterbalancing the tension that is applied to the cores 28a, 28b when the elongate films 24a, 24b are wound therearound, thus reliably preventing the cores 28a, 28b from being flexed. Thus, the elongate films 24a, 24b are prevented from being transported unstably, and are smoothly and reliably wound around the cores 28a, 28b, providing a stable wound configuration.

The first and second free rollers 320a, 320b are positioned at equal distances K from the hypothetical reference line LV. Therefore, the first and second free rollers 320a, 320b are stably and firmly supported on the output circumferential surfaces of the cores 28a, 28b, and the block 317 on which the first and second free rollers 320a, 320b are mounted does not need to rely on its own rigidity, allowing the gap 319 to be maintained reliably

between the block 317 and the cores 28a, 28b.

The elongate films 24a, 24b can thus smoothly be wound along the gap 319 and hence can be wound efficiently and highly accurately. The fourth free roller 334 is disposed in substantially opposite relation to the first and second free rollers 320a, 320b about the cores 28a, 28b, thereby reliably supporting the cores 28a, 28b.

The third free roller 332 and the winding nip roller 402 are disposed on the hypothetical reference line LH in opposite relation to each other about the cores 28a, 28b. Therefore, pressing forces applied by the third free roller 332 and the winding nip roller 402 are held in equilibrium, preventing the cores 28a, 28b from being flexed along the hypothetical reference line LH.

A predetermined number of block wrappers 60 corresponding to the axial length of the cores 28a, 28b are arrayed in the axial direction of the cores 28a, 28b, and apply pressing forces to the cores 28a, 28b over their entire length. Accordingly, uniform pressing forces can be applied to the cores 28a, 28b in the entire axial direction, so that the cores 28a, 28b can be maintained linearly over their entire length. Specifically, as shown in FIG. 19, if the cores 28a, 28b held by only the core chucks 90a, 90b are rotated by the core rotating mechanism 58 to wind the elongate films 24a, 24b around the cores 28a, 28b, the cores 28a, 28b are liable to be largely flexed in their central region. However, as shown in FIG. 20, when the cores 28a,

28b are rotated while pressing forces are being applied to the cores 28a, 28b over their entire length by the block wrappers 60, the cores 28a, 28b can be maintained linearly over their entire length, preventing the wound configuration of the elongate films 24a, 24b from being disturbed.

By setting dimensions of the gaps 319, 331 between the blocks 317, 329 and the cores 28a, 28b, it is possible to wind the elongate films 24a, 24b neatly around the cores 28a, 28b. Specifically, when the base of the elongate films 24a, 24b was made of PET, the elongate films 24a, 24b had a thickness of 0.1 mm, the outside diameter of the cores 28a, 28b was in the range from 50 mm to 90 mm, and the gaps 319, 331 were in the range from 0.1 mm to 0.8 mm, i.e., in the range from the thickness of the elongate films 24a, 24b to 0.8 mm, a stable wound configuration was obtained. When the gaps 319, 331 were in the range from 0.8 mm to 1.2 mm, the elongate films 24a, 24b tended to float from the cores 28a, 28b. When the gaps 319, 331 were greater than 1.2 mm, the wound state was unstable, and a winding failure was caused. Therefore, the gaps 319, 331 should preferably be in the range from the thickness of the elongate films 24a, 24b to 0.8 mm.

According to the second embodiment, furthermore, the block 317 with the first and second free rollers 320a, 320b mounted thereon is movable toward and away from the cores 28a, 28b by an actuator with a pressing force adjusting function, e.g., the vertical cylinder 310. The tension of

the elongate films 24a, 24b when they are wound around the cores 28a, 28b is in the range from 9.8 N (Newton) to 29.4 N (Newton) per 100 mm of the film, and is controlled by the torque produced by the servomotor 92 of the core rotating mechanism 58. The servomotor 92 may be replaced with a combination of an induction motor and a powder brake, a combination of an induction motor and a hysteresis clutch, or a combination of a speed-controlled motor and a dancer.

The pressing forces of the upper wrapper 300 are set by a regulator to be of the same value as the above tension value. For example, in the case where the block wrapper 60 has a width of 100 mm, the cylinder 310 has a bore diameter of 10 mm, and the upper wrapper 300 has a weight of 4.9 N (Newton), if the film tension value is 19.6 N (Newton) per 100 mm, then the pressing forces of the upper wrapper 300 are 18.6×10^4 Pa (Pascal).

The cores 28a, 28b are apt to have a more flexible region in the axial direction thereof. If, for example, the pressing forces of the block wrapper 60 disposed at the centers of the cores 28a, 28b are higher than those of the other block wrappers 60, then the cores 28a, 28b can accurately be corrected out of their flexed configuration.

If there is employed a mechanism capable of automatically controlling a pressure in ganged relation to the set tension value of the elongate films 24a, 24b when they are wound, then transverse film sizes can be changed automatically when the tension is changed according to

transverse film size. By individually controlling the cylinders 310 of the respective block wrappers 60, the cores 28a, 28b can be pressed so as to be slightly flexed in a direction opposite to the direction in which it is flexed under tension. Accordingly, the stability with which to transport the elongate films 24a, 24b is increased to reliably obtain a stable wound configuration.

In the second embodiment, the winding nip roller unit 400 is employed. However, the winding nip roller unit 400 may be replaced with a winding nip roller unit 400a shown in FIG. 21. The winding nip roller unit 400a has a cylinder 570 for moving the winding nip roller 402 in the directions indicated by the arrow C. The cylinder 570 has a rod 572 extending therefrom and coupled to a movable upper plate 408a supporting the winding nip roller 402 thereon. The winding nip roller 402 is movable in unison with the movable upper plate 408a when the cylinder 570 is actuated.

The elongate films 24a through 24d have been described as a web. However, the present invention is also applicable to any of various webs including resin sheets, paper, etc.

According to the present invention, as described above, the web is initially wound around the core under a low tension, thereafter wound under a tension that increases at a given rate, and then wound under a tension that progressively decreases from the high tension. The web thus wound into a roll is not damaged and the roll is in a neatly wound state free of edge undulations or irregularities on

its end faces.

The length to which the web is wound around the core under a low tension is set so as to correspond to the length of the core, so that the web can be neatly wound around the core without the danger of the core becoming flexed.

According to the present invention, the core is rotated while a plurality of rollers and blocks are disposed around the core, and the rollers and blocks are retracted away from the core successively from regions where the leading end of the web has passed. Accordingly, only the leading end of the web is kept on the outer circumferential surface of the core, and the web is not loosened under the tension of the web. A high-quality wound product with a desired wound configuration maintained reliably can efficiently be obtained through a simple process.

According to the present invention, furthermore, there is disposed a movable pressing roller which is pressed against the core in a direction opposite to the direction in which the tension of at least the web is applied, to keep the tension of the web and the pressing forces applied by the pressing roller in equilibrium. Consequently, when the web is wound around the core, the core is prevented from being flexed under the tension of the web, making it possible to reliably obtain a stable wound configuration with a simple arrangement.

Although certain preferred embodiments of the present invention have been shown and described in detail, it should

be understood that various changes and modifications may be made therein without departing from the scope of the appended claims.